

# Oxy CO<sub>2</sub> EOR Project Occidental of Elk Hills, Inc.

May 21, 2010



#### **Outline**



- Oxy CO<sub>2</sub> Business
- HECA Project Description
- Oxy CO<sub>2</sub> EOR Project Description
- Site Suitability for Sequestration

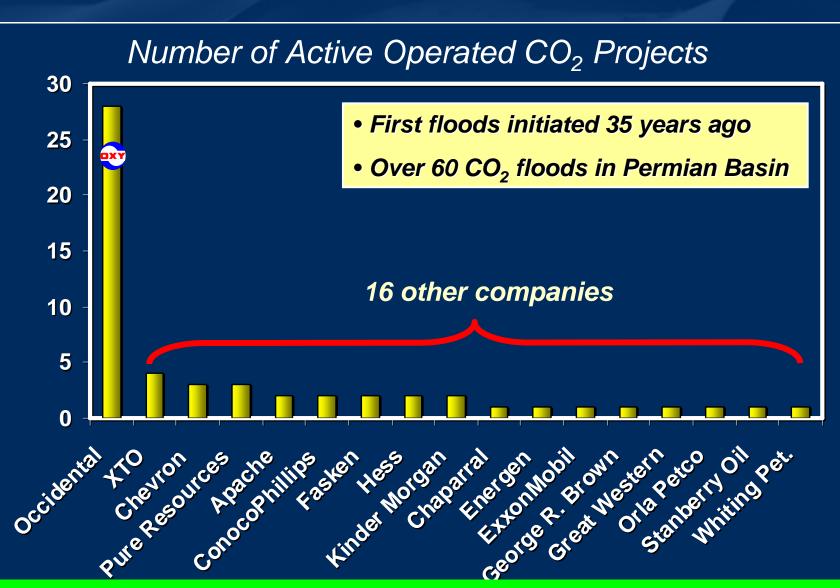
# CO<sub>2</sub> EOR in the United States





## CO<sub>2</sub> Floods in the Permian Basin

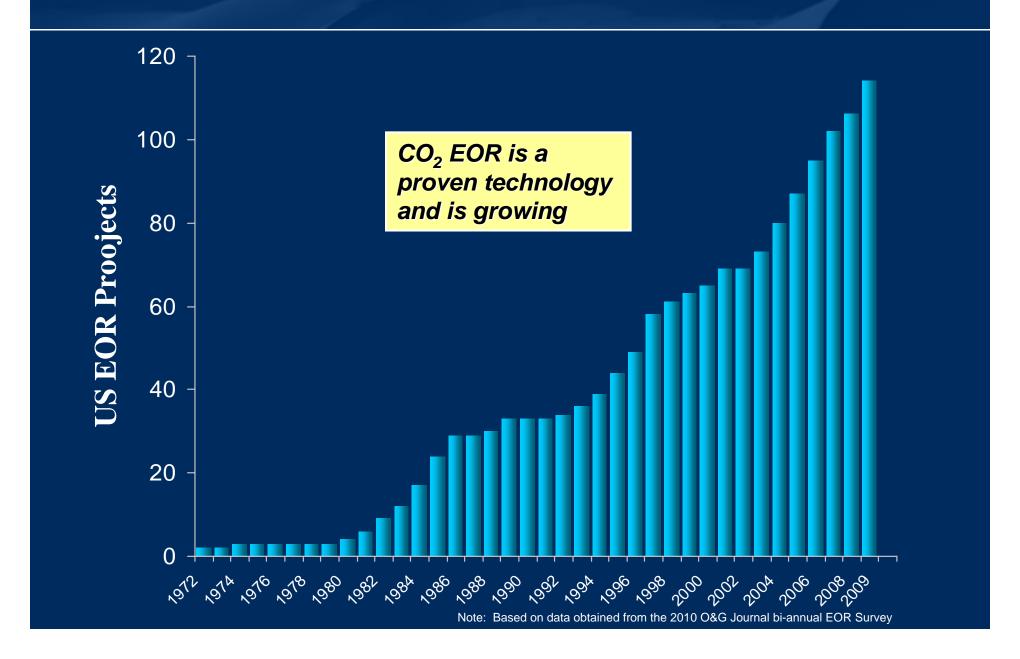




Oxy transports and injects more CO<sub>2</sub> than any other company in the world

# CO<sub>2</sub> EOR is Growing





# Oxy Operated CO<sub>2</sub> Projects

(Date Started)



- North Cross (1972)
- **GMK South (1982)**
- Denver Unit (1983)
- Central Mallet (1984)
- Frazer Unit (1984)
- Slaughter Estate (1984)
- **Wasson ODC** (1984)
- South Wasson Clfk (1985)
- Willard Unit (1986)
- **South Cross** (1988)
- Salt Creek Unit (1993)
- South Welch Unit (1993)
- Cedar Lake Unit (1994)
- Elmar Delaware Unit (1994)
- Bennett Ranch Unit (1995)

- North Cowden Unit (1995)
- Anton Irish Clfk Unit (1997)
- Mid Cross (1997)
- North Dollarhide Dvn (1997)
- West Welch Pilot (1997)
- Sharon Ridge Unit (1999)
- TSTAR Abo (1999)
- Cogdell Unit (2001)
- HT Boyd (2001)
- North Hobbs Unit (2003)
- Levelland Unit (2004)
- Igoe Smith Unit (2005)
- West RKM (2006)
- North West Mallet (2007)

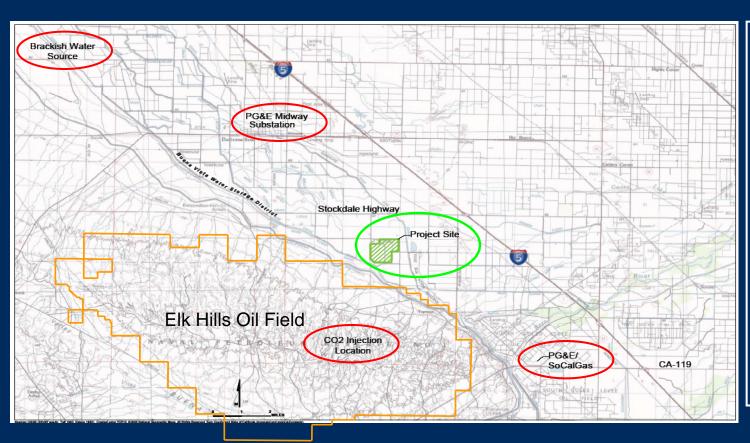
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#### **HECA Site Location**





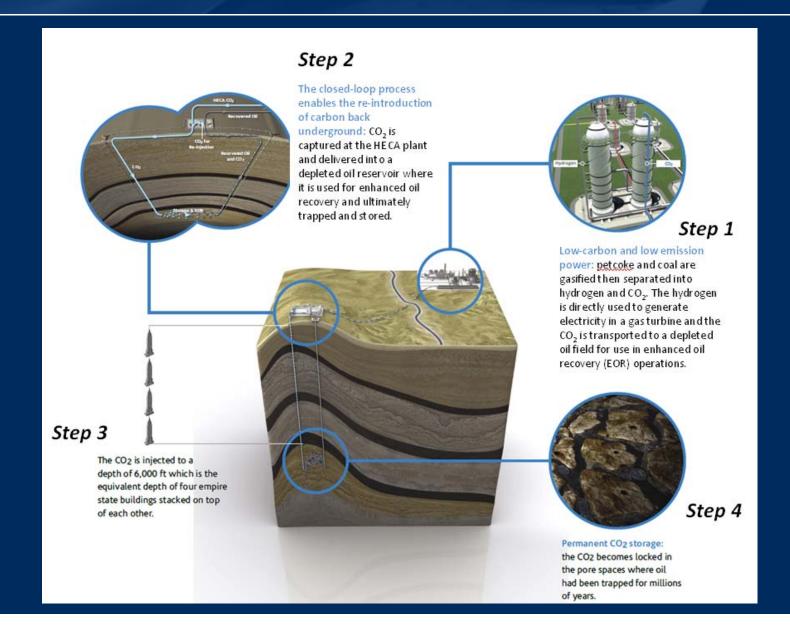
# HECA site close to:

- CO<sub>2</sub> injection point and geologic storage formation
- Adequate non-potable water supply
- Electric transmission system

Sources: USGS (30'x60' quads: Taft 1982, Delano 1982). Created using TOPO!, ©2006 National Geographic Maps, All Rights Reserved. Kem County and State of California (proposed and approved projects).

# HECA / Oxy Integrated System





#### **Outline**

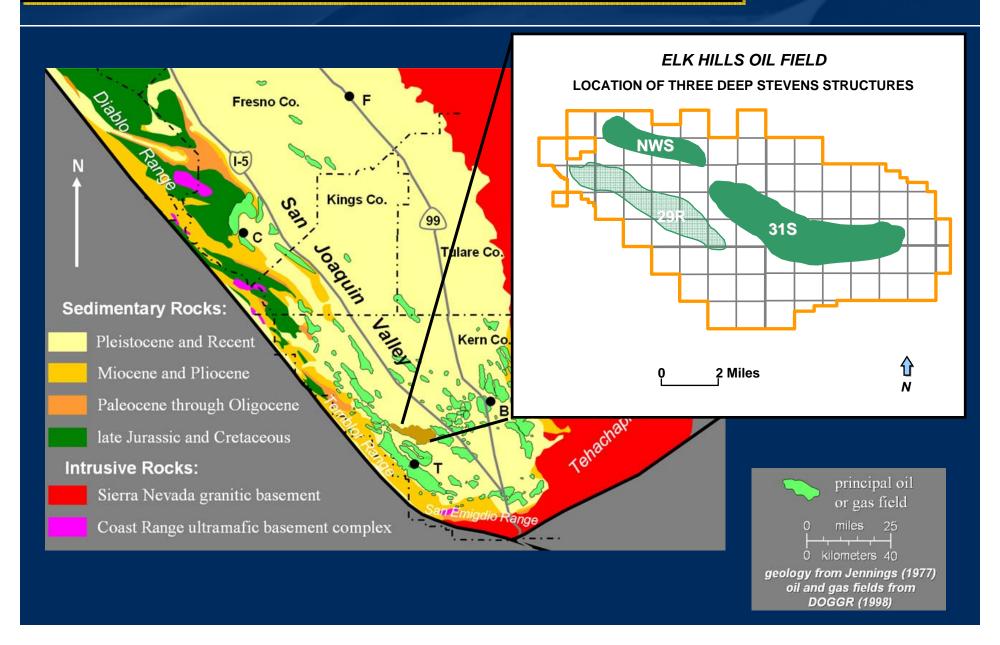


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# Oxy CO<sub>2</sub> EOR Project Site Location

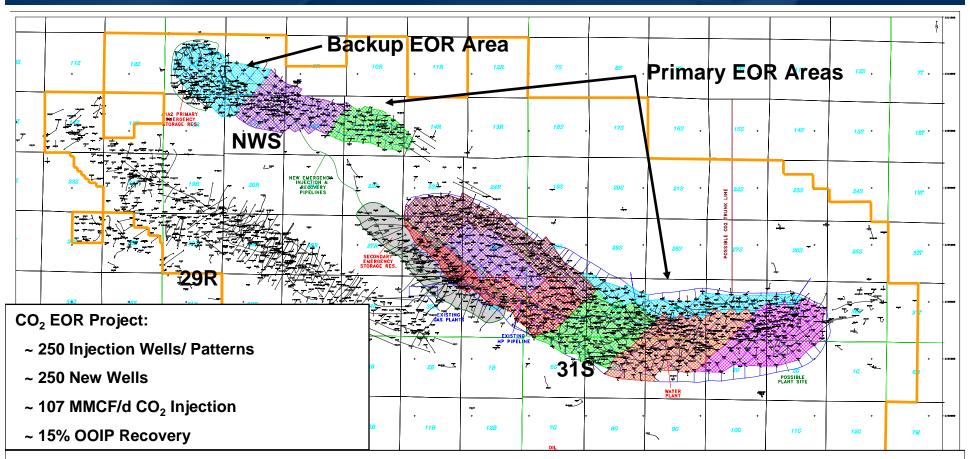
Southern San Joaquin Valley





# Conceptual Stevens Phased Development



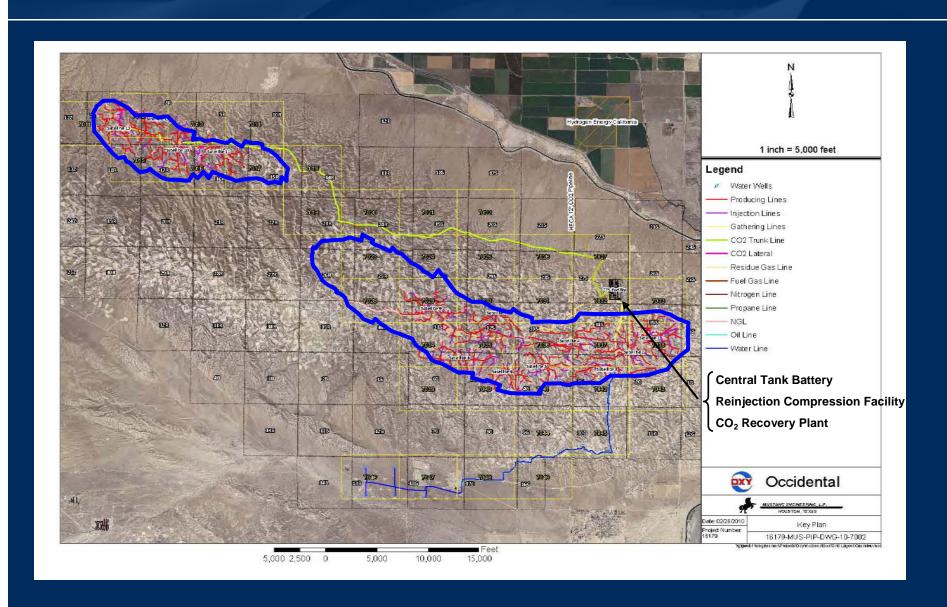


#### 31S & NWS Stevens Reservoirs contain:

- 640 active producing wells, 185 active injection wells
- Over 7.5 billion Bbls reservoir pore volume
- Sequestering 20 yrs CO<sub>2</sub> off-take from HECA will require less than 1 billion Bbls reservoir pore volume

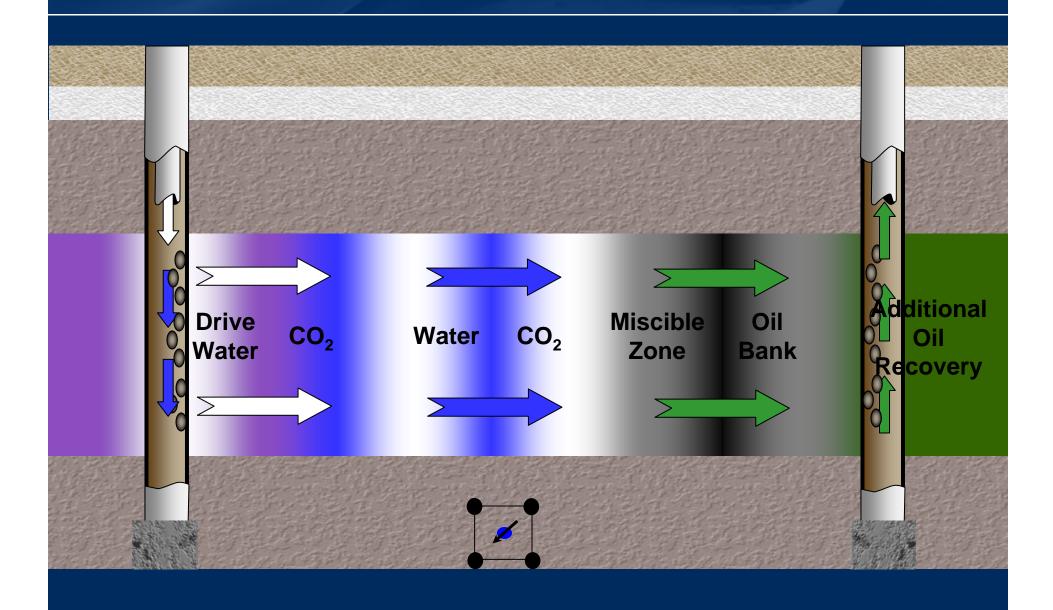
# HECA / Elk Hills Location Map





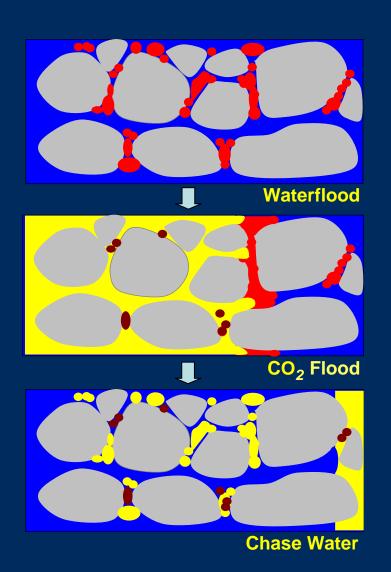
# What is the CO<sub>2</sub> Water-Alternating-Gas (WAG) Flood Process?





# **Predictions of CO<sub>2</sub> EOR & Trapping** via integrated Reservoir Modeling Study





#### CO<sub>2</sub> EOR Physics

Water injection (blue) recovers oil in large pores; leaving trapped oil (red) in small pores

CO<sub>2</sub> (yellow) dissolves and displaces trapped oil; leaving only heavy ends (brown) in the reservoir.

Frequently, chase water is injected after  $CO_2$ . In this case, a significant fraction of  $CO_2$  is trapped / retained by the injected water.

#### Nexus Between CO<sub>2</sub> EOR and CO<sub>2</sub> Sequestration

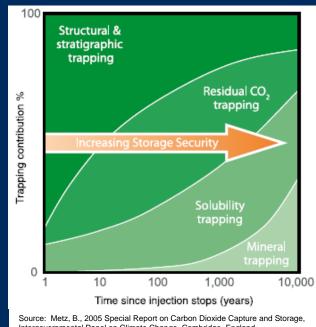


# CO<sub>2</sub> EOR Results in Sequestration

During each CO<sub>2</sub> injection cycle, 30 – 50%
CO<sub>2</sub> is typically unrecoverable and sequestered with each pass through the

reservoir

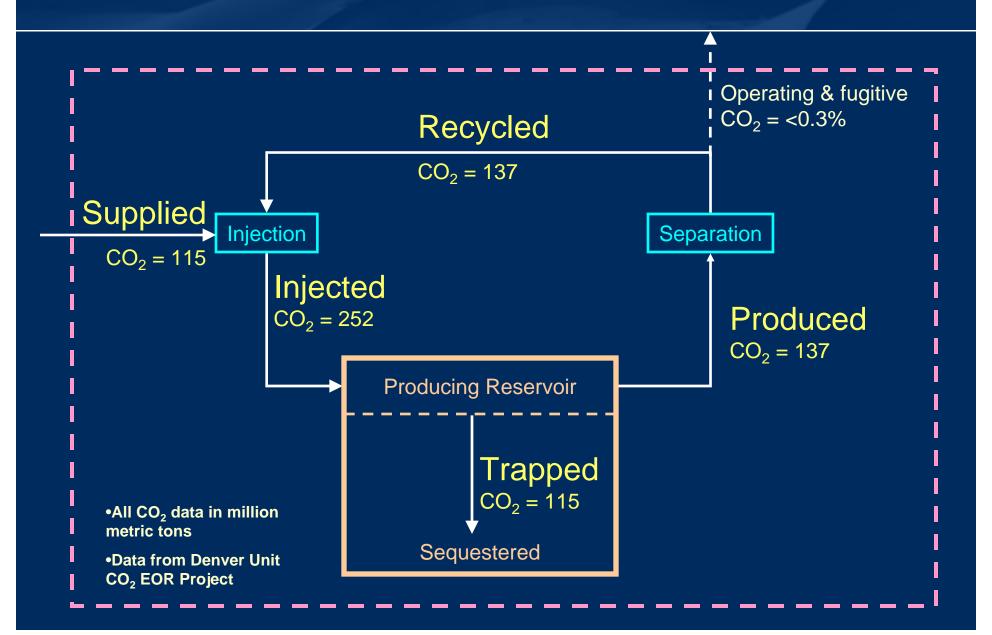
When field no longer produces economic oil/gas rates, all wells will be plugged according to regulations, trapping all CO<sub>2</sub> in the reservoir



Source: Metz, B., 2005 Special Report on Carbon Dioxide Capture and Storage Intergovernmental Panel on Climate Change, Cambridge, England. <a href="http://www.ipcc.ch/publications">http://www.ipcc.ch/publications</a> and data/publications and data reports carbon dioxide.htm.

# CO<sub>2</sub> Material Balance – Closed Loop





# Major Surface Project Components



- CO<sub>2</sub> Injection and Recovery Equipment
  - CO<sub>2</sub> Supply System
  - Satellite Gathering Stations
  - Infield Gathering and Injection Distribution Pipelines
- Recovered CO<sub>2</sub> Purification and Compression
  - Central Tank Battery Test (CTB)
  - Reinjection Compression Facility (RCF)
  - CO<sub>2</sub> Recovery Plant (CRP)
  - Produced Water Injection Plant
- Backup CO<sub>2</sub> EOR Injection Facility

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## Regulatory Requirements – Class II UIC



# Engineering Study

- Reservoir characteristics (porosity, permeability, thickness, area, frac gradient, temp., press., saturations)
- Reservoir fluid data (gravity, viscosity, quality)
- Casing diagrams all wells (cement fill, cement plugs & evidence no well adversely affects projects)
- Planned drilling & well work to support project (map of all well locations, purpose & unit boundaries)

## Geologic Study

- Structural contour map on all injection zones
- Isopachous map of all injection zones
- Geologic cross-section through injection well
- Geophysical logs of all zones & aquifers

# Supplements to Class II Requirements

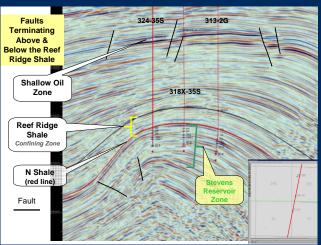


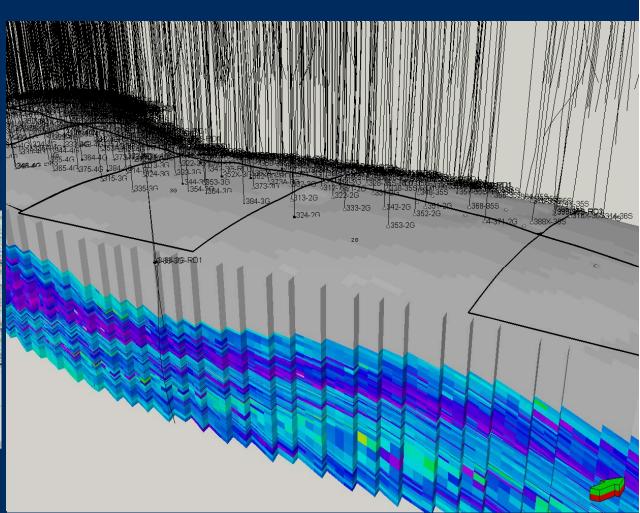
- Engineering Study
  - Original reservoir fluid contacts
  - Current reservoir pressure differences
  - Reservoir capacity calculations
- Geologic Study
  - Cap rock characteristics
  - Structure defined using sonic imaging
  - Core analysis
  - Geochemical analysis
- Measurement, Verification and Reporting Plan Being Developed

# Engineering and Geologic Understanding



~2,450 Wells drilled 1998-2009

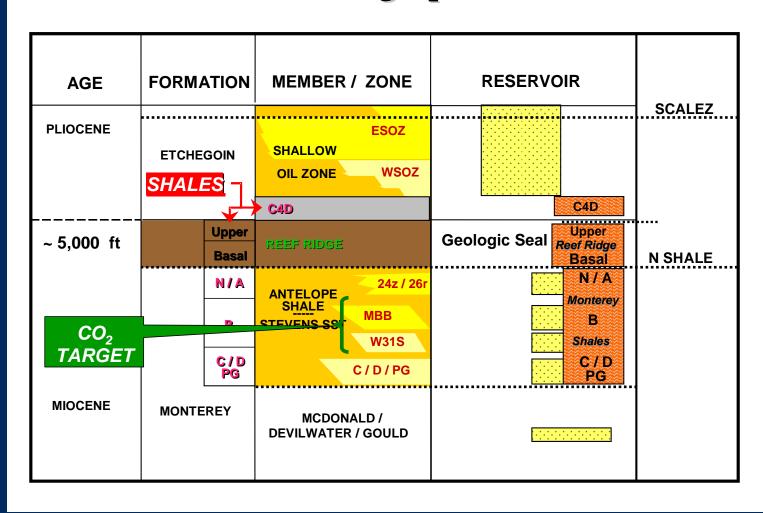




# Elk Hills Stratigraphic Section



#### Elk Hills Stratigraphic Section



#### Additional Confirmation of Containment



- Reef Ridge Core Analysis
  - Mineralogy
  - Oil Saturation
- Extensive Structural Imaging Data
- Geochemical Analysis
  - Supports Vertical Isolation

# Site Suitability Summary



- Comprehensive knowledge of field history & geology
- Stevens reservoirs are ideal for EOR / sequestration
- Class II UIC permit needed
- HECA CO<sub>2</sub> sequestration will need to be measured, verified & reported

